Fig. 4: Map of known collecting localities for the brush-finch *Atlapetes pileata*, overlain on a map of regions fitting the modeled ecological needs of the species (in gray), showing an old coastal locality in Tamaulipas as falling outside of the species' ecological niche.

build an ecological model and identify areas of appropriate and inappropriate ecological conditions for the species (Fig. 4). The modeling algorithm used is detailed elsewhere (Stockwell & Noble 1992; Stockwell 1999; Stockwell & Peters 1999; Peterson 2001; Peterson et al., in press), but the result is that all known occurrence points fall into areas predicted to be appropriate for the species except one. This point (Fig. 4) represents an old locality on the coast of Tamaulipas, in the lowlands of eastern Mexico. The ecological modeling procedure identifies this site as a specimen locality that is not within the ecological possibilities of the species, and most likely represents an erroneous locality designation.

Like the collector itinerary approach, a procedure based on ecological niche modeling could be implemented as an error detection facility. A computer could periodically scan the pooled data resources for known occurrence points of each species, build ecological niche models for each species, and detect occurrence points that fall outside the ecological limits of the species. These points can then be flagged for checking by curators or collections staff.

7.4 Community-wide Activities: The Power of Numbers

Much more generally than for the preceding examples, it is important to emphasize the power of working of a community. When a proposal stems from a Division of Mammalogy at a particular museum, it carries far less force than a proposal that comes from all of the Mammalogy divisions from 17 institutions. This power of numbers – working as a community – makes possible many bold new funding initiatives.

Indeed, in the Species Analyst effort, several such community proposals have already been prepared, and have proven enormously successful. Proposals have been prepared and funded for a pilot North American bird network (U.S. National Science Foundation, funded 1998), a 15-member fish data network (U.S. National Science Foundation and U.S. Office of Naval Research, funded 2000), and a 17-member mammal data network (U.S. National Science Foundation, funded 2001). This success clearly results from the community nature of the proposals, and has resulted in more than $2 million of new funding being available to the systematics collections community.

More generally, community efforts constitute an important step towards demonstrating the power of the systematics collections community in many real-world challenges. Work as a community shows the true analytical power of the data that the systematics collections community holds. This power is a key in convincing funding agencies, museum administrators, and decision-makers in general of the importance of systematic collections.

8. CONCLUSIONS

The point of this piece is that computerization is not a prohibitively difficult or expensive endeavor; rather, it is an important step in curating a collection that more than pays for itself in (1) saving time and effort in curatorial activities, (2) improving data quality and removing erroneous elements, and (3) improved funding possibilities and recognition by administrators and decision-makers. Most important is to make some simple decisions, start into the task, and methodically carry it out.

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Linking Specimens and Collectors - a Pilot Study (The Th. Angele Bird Collection and the Database ZOBODAT)

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Abstract. The geographical database ZOBODAT (www.biologiezentrum.at) aims to contribute to the understanding of biodiversity by offering an interactive information system for scientists, nature protection and the public. Linking specimen data with biographical information about collectors is a new development towards this aim in order to provide as much interrelated information as available. The new possibilities presented lead the user from specimens to collectors and vice versa, thus giving insight into collection and collecting history, a field of natural history still poorly investigated.

The collection Th. ANGELE (museum of Upper Austria) comprises 1,473 specimens, mainly birds of prey and owls, collected between 1895 and 1925. It was chosen for this pilot study because of the world-wide origin of specimens and their widely distributed collectors. 49 out of 67 collectors' names could already be identified according to biographical sources. Still open questions will hopefully be answered when the whole system is run via the world wide web and therefore open to a wide forum of prospective contributors of biographical information.

Technical details concerning the database are presented.

Key words. Biodiversity database, bird collection, collection history, biographies, Th. Angele collection, Austria

1. INTRODUCTION

The biogeographical database ZOBODAT (www.biologiezentrum.at) aims to contribute to the understanding of biodiversity by offering an interactive information system for scientists, nature conservationists and the public (MALICKY & AUBRECHT 2001).

Historically biogeographical databases were developed mainly for the technique of plotting distribution maps. This goal has become especially important with the rise of biodiversity research as a focal conservation issue (BIBBY et al. 1992). GIS techniques now contribute to interpreting species distribution patterns on all geographical scales. Results increase with the availability of geographically based information layers comprising non-biotic and biotic parameters.

Museum specimen information systems have to deal with additional parameters linked to biological specimens like persons involved in collecting, determination and revision. The mode of preparation and type specimens must be documented as well.

Meanwhile discussions have started and prototypes are being developed for linking decentralized biodiversity databases on regional and global levels (The Species Analyst, Univ. Kansas, USA- www.habanero.nhm.ukans.edu/; ENHSIN – European Natural History Specimen Information Network – www.nhm.ac.uk/science/rco/enhsin/; ENBI - European Network of Biodiversity Information, European Union – www.faunaeur.org/enbi).

Common taxonomic reference lists available for all contributors will be one of the focal points for the future success of these projects (Species 2000 – www.sp2000.org/ and Fauna Europaea – www.faunaeur.org/).

By technical means, the world-wide-web already offers the communication medium as far as databases can provide the standards needed.

The aim of our pilot project was to link specimen data with biographical data in order to provide insight into collection and collecting history. Such information is urgently needed for interpreting and reconstructing historical collections and for better understanding the fate of individual specimens and the scientific information they contain.

For demonstrating the function and use of such links in a pilot project we used the bird collection Th. Angele and the database ZOBODAT, both located at the biology centre of the Museum of Upper Austria.

The development and testing of new database queries and links is also carried out within the frame of the European Union project ENBI.

2. BIRD COLLECTION THEODOR ANGELE

This collection comprises 1,473 specimens, mainly birds of prey and owls from all over the world, purchased by Theodor ANGELE from different collectors and dealers of natural history specimens between 1895 and 1925.

A special part of the „Angele-collection" are bird specimens from Natal collected by A.G.J. RUDATIS. 331 specimens can be directly contributed to this collector (AUBRECHT et al., in print).

After ANGELE's death in 1926 the Museum of Upper Austria became care-holder of his collection in 1927 and bought it in 1941. Th. KERSCHNER, curator of the zoological collections, started to take into inventory and determinate all specimens (KERSCHNER 1942). In a big exhibition most of the specimens were presented to the public in Linz during October 1953 (KLOIBER 1953, 1954, 1955; TRATZ 1954). From this time until 1980 Mrs. G.Th. MAYER was curator for this collection and worked on improving the inventory-data and in preserving the specimens. All mounted specimens were screwed in wooden boxes and thus were well preserved during these decades.

Since the mid-1990s G. AUBRECHT, J. PLASS and S. WEIGL started to work on the collection. All specimens were re-investigated for proper determination together with A. GAMAUF and H. SCHIFTER (NHMW, Natural History Museum Vienna) by means of new literature, and data were digitized in a data-base. All information available originates from the original specimen labels and inventory books. Only very few correspondence of Th. ANGELE with collectors and natural history dealers could be found especially concerning sales negotiations when ANGELE wanted to dispose of his collection in the 1920s.

3. THEODOR ANGELE

*5.4.1847 Erolzheim, Württemberg, Germany, † 28. 6. 1926 Linz, Austria, studied at the Technical University in Stuttgart and started a career as railway engineer with numerous projects in the Austrian-Hungarian monarchy in 1869. 1871 he married J. RÖSSLER in Iglau (4 children). After his wife's death he married a second time in 1882, P. SCHWAB (4 children). As railway engineer he worked in Austria, Moravia, Bohemia, Silesia, Galicia, Hungary, Siebenbürgen, Bukowina and Romania (ASCHAUER 1964) and founded his own firm in 1875. In 1897 he started a cooperation with Th. HOCK (HOCK & ANGELE, Linz, until 1905).

From 1889 until 1893 he lived in Brno, Moravia (now Czech Republic), where he became member of the „Naturforschende Gesellschaft Brünn" in 1891 (ANONYMUS 1892).

As an ardent hunter he began playing with the idea of ccomposing a world-wide collection of birds of prey and owls in 1892. Since 1894 he kept his residence in Linz, Austria. From 1895 until 1915 (irregularly until 1925) he devoted his spare-time to building up his bird-collection, consisting mainly of birds of prey and owls, using personal links and sales offers of natural history dealers all over the world. Th. ANGELE did not publish a single word about his huge collection.

4. DATABASE ZOBODAT

ZOBODAT (Zoological-Botanical Database, former ZOODAT) is a digitally organized biogeographical database including facilities for analysis, documentation and communication (MALICKY & AUBRECHT 2001; REICHL 1986; MALICKY 1998). Founded 1972 by Univ. Prof. Dr. Ernst Rudolf REICHL, ZOBODAT was taken over by the federal country of Upper Austria in 1999. It is now located at the Biology Centre of the Museum of Upper Austria.

The database comprises information about the temporal and spatial distribution of animal and plant species and various supporting information topics. Most of the data refer to insects taxonomically and to Austria geographically. But ZOBODAT can be used for all groups of organisms and world-wide. Besides plotting traditional distribution maps, new goals include user friendly analysis which enable rapid retrievals of information about certain geographical areas and site-specific conservation matters. Special user accounts provide a differentiated data protection.

A comprehensive survey about the recent structure of ZOBODAT is given by MALICKY & AUBRECHT (2001). Data for input can be provided on standardized lists or via desctop database-systems like MS-Access or dbase. Meanwhile people and institutions contributing to ZOBODAT have full access to their own data and to ZOBODAT's documentation programs via the internet by holding special user identifications.

Staff:

Biology: Dr. Gerhard AUBRECHT

Technical part: D.I. Michael MALICKY

Technical development:

IBM 1130 (1972-1975)

IBM 370 - Mainframe (1975-1993)

Software: TSO, PL/I, FORTRAN

Intel 80486 - Personal Computer (1993-1999)

Software: Windows NT, Oracle, PLSQL, C

Intel Dual PII 350 - Databaseserver, Intel PII 400 - Webserver (since 1999)

Software: Linux, Postgresql, Grass GIS, Apache Webserver, PHP

Table 1: Geographical and taxonomical contents of the database ZOBODAT: (online Top 10, Dec. 2001) AUT = Austria

Area	No. records
Upper Austria, AUT	572,076
Lower Austria, AUT	386,378
Carinthia, AUT	259,323
Tyrol, AUT	233,083
Styria, AUT	213,316
Salzburg, AUT	184,886
Romania	101,172
Italy	93,972
Vorarlberg, AUT	93,944
Burgenland, AUT	69,512

Taxa	No. records
Lepidoptera	1,494,891
Coleoptera	453,532
Hymenoptera	88,499
Trichoptera	58,788
Mollusca	47,976
Homoptera	22,802
Arachnida	17,462
Aves	8,189
Diptera	7,719
„Vermes“	7,562

5. PILOT STUDY - LINKING SPECIMENS AND COLLECTORS

The documentation of the collection Th. ANGELE is still progressing. For the pilot study names of collectors and natural history dealers have been identified on specimen labels. By literature study and the help of numerous colleagues biographic information of collectors has been gathered for gaining short biographies and available photos. Of course this process is a „never-ending“ one and a number of questions are still open concerning unidentified or poorly documented cases. In the near future this information will be freely accessible via the internet and will hopefully bring new biographical results.

Table 2: Collectors of Coll. Th. ANGELE with biographical information available

Collector	year of birth and death	selected literature source
Angele, Theodor	1847 - 1926	Kerschner (1942)
Barlow, Chester	1874 - 1902	Taylor (1903)
Blanc, Marius	1857- 1944	Horn et al. (1990)
Blohm, Wilhelm	1875 - 1944	Gebhardt (1964)
Boucard, Adolphe	1839 - 1905	Mearns & Mearns (1998)
Briceno, Gabaldon L.	?	Phelps (1944)
Dombrowski, Robert	1869 - 1932	Schuster (1933)
Dybowski, Benedikt	1833 - 1930	Gebhardt (1964)
Erlanger, C. V. Heinrich	1872 - 1904	Kleinschmidt (1905)
Fleck, Eduard	1841(3) - 1917	Gunn & Codd (1981)
Franke, Rudolfo	?	pers. comm. S. Eck
Fritsche, Karl	?	Archiv Biol. centre, Linz
Führer, Ludwig	1866 - 1937	Gebhardt (1964)
Garlepp, Otto	1864 - 1959	Niethammer (1972)
Geisler, Bruno	1857 - 1945	Gebhardt (1964)
Harvie-Brown, J. A.	1876 - 1955	Love (1982)
Henseler, Carl	1876 - 1955	Horn et al. (1990)
Herron, Robert Byron	1859 - 1943	pers. comm. R. Quigley
Hildebrandt, J. Maria	1847 - 1881	Schalow (1881)
Hoffmanns, Wilhelm	1865 - 1909	Gebhardt (1970)
Humblot, Leon	1852 - 1914	Horn et al. (1990)
Kellen, Veth	?	Reichenow (1902)
Kny-Scheerer	?	Horn et al. (1990)
Kühn, Heinrich	1860 - 1906	Hartert (1907)
Lano, Alberto	1860 - 1928	Stone (1928)
Meek, Albert Stewart	1871(2) - 1943	Mearns & Mearns (1998)
Molnar, Lajos	1853 - 1942	Keve (1939-42)
Palmer, Mervyn Grove	1882 - 1954	Horn et al. (1990)
Penther, Arnold	1865 - 1931	Kühnelt (1978)

Table 2 continued

Collector	year of birth and death	selected literature source
Platen, C. Constantin	1843 - 1899	Gebhardt (1964)
Price, W. Wightman	1871 - 1922	Fisher (1923)
Reed, Carlos Samuel	1888 - 1949	Etcheverry (1993)
Reischek, Andreas	1845 - 1902	Aubrecht (1995)
Rolle, Franz Hermann	1864 - 1929	Gebhardt (1970)
Rosenberg, W. F. Henry	1868 - 1957	Mearns & Mearns (1998)
Rudatis, A. G. Hans	1875 - 1934	Gunn & Codd (1981)
Schlüter, Wilhelm	1828 - 1919	Schmidt (1919)
Schlüter, Willy	1866 - 1938	Kleinschmidt (1938)
Schrader, Gustav	1852 - 1942	Gebhardt (1964)
Schwanda, Ferdinand	?	pers. comm. H. Schifter
Thompson, Seton Ernst	1860 - 1946	Palmer (1947)
Tancré, Rudolf	1842 - 1934	Gebhardt (1964)
Teichmann, Otto	? - 1941	Gerber (1939-1941)
Tschusi zu Schmidhoffen, V.	1847 - 1924	Gebhardt (1964)
Umlauff, J. F. G.	?	Horn et al. (1990)
Voelschow, A. D. K. Martin	1866 - ca. 1940	Horn et al. (1990)
Weiske, Emil	1867 - 1950	Heyder (1964)

Table 3: Collectors of Coll. Th. ANGELE with biographieal information still unavailable

Collector	origin of specimen
Black, J.W.	N-America
Flickigg, E.	Siberia
Franklin, 1.	N-America
Garner, E.	N-America
Gebgardi	Russia
Gordon, Theodore	N-America
Guelf, G.F.	N-America
Krebs, A.	N-America
Leblanc, J.	E-Africa
Leizear	N-America
Lenssen, Robert	Brazil
Monthu, M.	N-America
Riedel, Georg	S-America, Ethiopia
Rodriguez, J.H.	Guatemala
Rostowsky	Venezuela
Schlegel (prob. not H. or R.)	S-America
Schnerrer	Cameroon
Witte Palob	Brazil
Wyszonirski, Ludwik	Russia

6. TECHNICAL PROCEDURE WITHIN THE DATABASE (D.I. M. MALICKY)

Within the database system ZOBODAT pathways were provided by linking relationally organized thematic files in order to gain easy access to related specimen information issues (Fig. 1). Most important was the possibility to enable the user to jump from species to specimen and to collector and vice versa and to combine this information with mapping the geographical components.

Example:

Query (1) for species *Buteo buteo*

Result: number of specimens referring to *Buteo buteo* (sub)species (Fig. 2), with possibilities for

– creating a list of specimens or

– map of listed specimens or

– link to NCBI-genbank

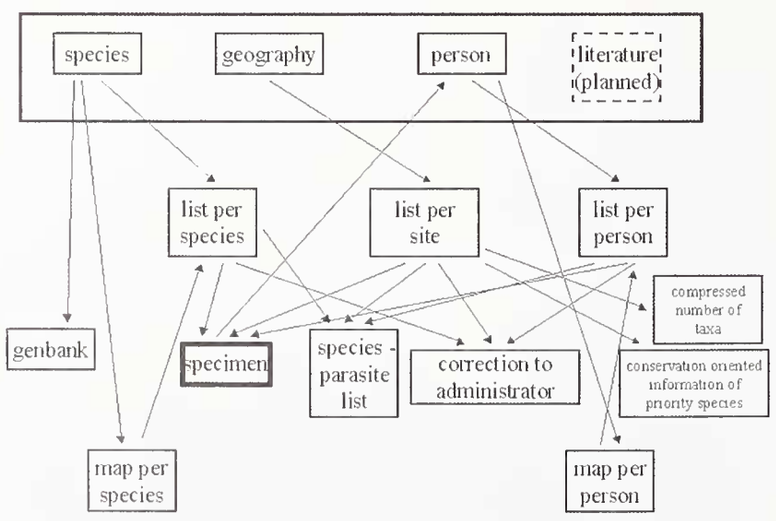

Fig. 1: Query pathways demonstrating the interactive functions and links within the database ZOBODAT, referring to species-related, site-related and person-related specimen information (M. MALICKY, Linz, Austria).

Stamm	Klasse	Ordnung	Familie	Gattung	Art	Unterart	Autor	Daten	Karte	NCBI Genbank
Chordata	Aves	Accipitriformes	Accipitridae	Buteo	buteo	arrigonii	Picchi, 1903	1	X	Nucleotide
Chordata	Aves	Accipitriformes	Accipitridae	Buteo	buteo	japonicus	Temminck & Schlegel, 1844	3	X	Nucleotide
Chordata	Aves	Accipitriformes	Accipitridae	Buteo	buteo	menetriesi	Bogdanov, 1879	4	X	Nucleotide
Chordata	Aves	Accipitriformes	Accipitridae	Buteo	buteo	vulpinus	Gloger, 1833	2	X	Nucleotide
Chordata	Aves	Accipitriformes	Accipitridae	Buteo	buteo		(Linnaeus, 1758)	148	X	Nucleotide

Fig. 2: Result of query 1: number of specimens referring to *Buteo buteo* (sub)species (ZOBODAT, Linz, Austria).

Query (2) for list of specimens referring to *Buteo buteo*

Result: list of specimens including collecting sites and dates (Fig. 3), with possibilities

– to look at individual specimen information,
– parasite data, or
– send correction of certain record information to administrator

Czernavoda, Rumänien	RO	28° 1' 0"E 44°22' 0"N	-	13. 2.1900	|	|	|	B P K
Czernavoda, Rumänien	RO	28° 1' 0"E 44°22' 0"N	-	19. 6.1902	|	|	|	B P K
Czernavoda, Rumänien	RO	28° 1' 0"E 44°22' 0"N	-	. .	|	|	|	B P K

Fig. 3: Result of query 2: Detail of list of specimens including collecting sites and dates (ZOBODAT, Linz, Austria).

Query (3) for an individual specimen from the specimen list

Result: names of person related to this specimen (Fig. 4) like
– collector,
– determinator,
– reviser,
– collection

with possibilities of looking at short biographies and photos

Belegtext1:

Belegtext2:

Leg: Robert Ritter von Dombrowski, Lainz bei Wien, Austria

Det: Anita Gamauf, NHMW, Wien

Rev:

Lit:

Conf:

Coll: Theodor Angele, Linz, Austria

Fig. 4: Result of query 3: names of person related to an individual specimen (ZOBODAT, Linz, Austria).

Query (4) for name collection Th. ANGELE

Result: short biography and photo of Th. ANGELE (Fig. 5), with possibilities to create

– list of all records of coll. ANGELE or

– map of all records of coll. ANGELE (Fig. 6)

Fig. 5: Result of query 4: Photo of Th. ANGELE (the short biography included in this query result is omitted here because already included in the text above) (ZOBODAT, Linz, Austria).

From this list one can again trace back to any individual specimen record.

Other query possibilities include searches for manually defined of pre-defined geographical regions with stepwise resulting site lists and specimen records.

For certain protected areas (pilot version) it is also possible to get compiled information of species or record numbers of higher taxa within chosen time periods (e.g. number of Piciformes species or records) or lists of priority species including the latest year of record.

Another query can start with names of persons, resulting stepwise in short biographies and lists of specimens referring to determinators, collectors or collections as shown above.

These interactive query functions are already installed in the database ZOBODAT and ready for further improvement and testing. In a next step we are going to include and to link literature sources to this system.

7. DISCUSSION

Including biographies into a biodiversity database is only one further step within the development of databases made possible by new technical improvements.

The history of biodiversity (historically biogeographical) databases shows interesting changes of paradigms. The first aim was to develop individual databases according to a wide range of taxonomic and geographical contents. Most databases tried to get monopoly status for certain taxa or regions. Nevertheless individual and technical developments led to a steady increase of newly founded databases mostly without consideration of common standards.

A change in thinking arose with the common availability of the world wide web's communication possibilities. Now it became apparently necessary to eval-

Fig. 6: Result of query 4: map of all located collecting sites referring to the collection Th. ANGELE. Collecting sites which do not exactly match geographical point information are included but not yet specifically made visible on this map by different symbols (ZOBODAT, Linz, Austria).